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Time-Series Analysis for Forecasting Climate Parameters of Kashmir Valley Using ARIMA and Seasonal ARIMA Model

Khalid Hussain[1], Fahad Farooq J.[1], Mir Salim N.[1], Sheikh Umar Farooq[2], and Insha Altaf[1]

1Department of Computer Science and Engineering, University of Kashmir, North Campus, Delina, Baramulla, India
2Department of Computer Science, University of Kashmir, North Campus, Delina, Baramulla, India

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Abstract

The Kashmir Valley, a sensitive ecological zone within the Indian Himalayan Region (IHR), demands urgent attention regarding climate change. Home to multiple rivers and glaciers, the region holds significant geopolitical and economic importance. This work presents an analysis of three major climate variables—precipitation, cloud cover, and temperature—in the Kashmir Valley by leveraging the CRU TS4.04 time series data from 1901 to 2021, thereby revealing some key and concerning trends. Further, this study aims to predict the future trends of these variables for the next 80 years (2020–2100) utilizing ARIMA and SARIMA models. The projections show a significant increase of approximately 2.0°C in the mean temperature, compared to 2019 levels by the end of the 21st century. The projections also point to a substantial reduction in the frequency of winter months experiencing mean temperatures below 2.0°C, potentially ceasing altogether by 2048, which could have devastating consequences for the region's ecosystem. The insights, gathered in this study, may serve as a presage for the concerned government and stakeholders and will pave the way for the development of robust and efficient plans to tackle climate change in the area. The findings also shed light on the limitations of the ARIMA model, particularly its inability to forecast erratic changes in climate variables, thereby emphasizing the need for more sophisticated approaches to capture the complexities inherent in regional climate systems.

Keywords: *ARIMA; Climate; Kashmir Valley; Analysis; Time-series Forecasting; Weather.*

1. Introduction

Climate change is a pervasive phenomenon, manifesting as prolonged alterations in diverse climate variables, notably temperature and precipitation, within a given region. The scope of the investigation may encompass a localized area or extend to dimensions as vast as a continent or the entire globe. Rigorous studies, dedicated to comprehending climate change, typically involve meticulous analyses of fluctuations in various climatic parameters, aiming to gauge the magnitude of alterations occurring within the specified region over defined periods. The climate time-series data can have trends (long-term changes in the data) and seasonality (changes and variations in the data that occur regularly at short intervals). Accurate predictions and estimations of the impending alterations in a region are indispensable for effective planning and management of natural disasters such as floods, droughts, and extreme temperature events. Recognizing the gravity of climate change, the United Nations Organization (UNO) underscores its significance, calling it a "defining issue of our time" and the present era as a "defining moment" (Nations Organization United, 2021), emphasizing the urgency for immediate global actions to analyze, prevent, and address climate change in diverse regions. A 2007 Intergovernmental Panel for Climate Change (IPCC) report by UNO highlights the potential damages associated with a 2.0°C rise in global temperatures (IPCC, 2007). However, recent findings from a special report on global warming caution that adverse impacts may occur even with a 1.5°C increase (IPCC, 2022). The IPCC's 2021 report amplifies concerns, branding the current global climate scenario as "code red for humanity" (IPCC, 2021). The dire consequences of climate inaction are expounded in the IPCC's Assessment Report-6 of the year 2023, which underscores the colossal risks and the imperative for unprecedented changes on a global scale. While the report provides unprecedented insights into the gravity of the climate emergency, it also highlights the critical need for immediate, substantial, and efficacious efforts to analyze, mitigate, and potentially reverse the climate change trajectory (IPCC, 2023).

Despite the global scale of efforts to combat climate change, certain regions warrant increased focus due to the potential catastrophic consequences, arising from adverse climate effects in these specific areas. A prime example is the Kashmir Valley, strategically positioned at an elevation of 1600 meters above sea level in the North-Western corner of the Himalayas, with an area ranging from (33.25◦N, 73.75◦E) to (34.5◦N, 75.25◦E) and geopolitically divided between India and Pakistan as shown in Figure 1. The region's environmental, geographical, and economic significance is substantial. The region is considered to have a sub-tropical climate, which is sometimes also classified as Sub-Mediterranean due to the rainfall distribution pattern (Meher-Homji, 1971). Mild summers and severe winters are considered characteristic features of the climate in the region. Multiple rivers such as Jhelum, Lidder, etc.,

* Corresponding author e-mail: suf.cs@uok.edu.in